Switched Reluctance Motors

Driving and Control by ST52

STMicroelectronics

Switched Reluctance Motors

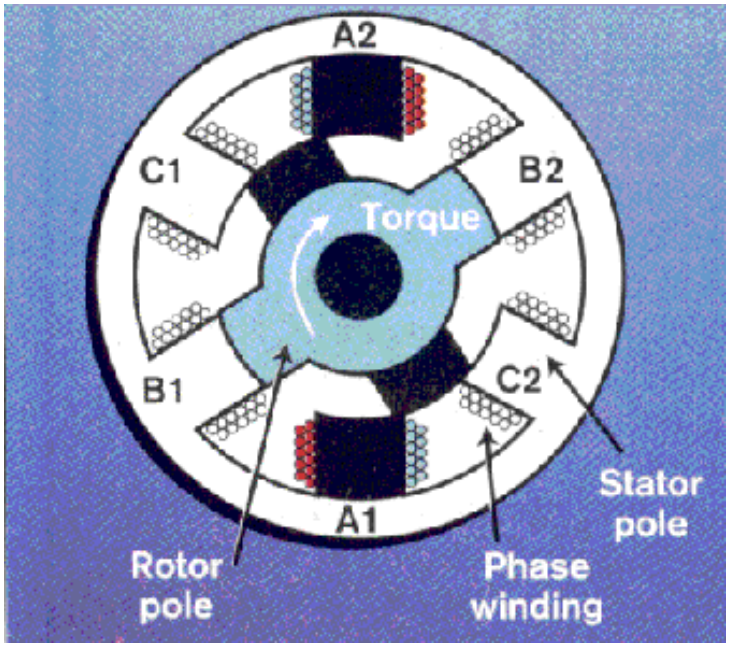
Switched Reluctance Motors (SRM) are step-motors where both stator and rotor have salient poles. No permanent magnets are used, therefore the magnetic flux is produced by means of the stator coils. The speed is controlled by varying the frequency of the voltage control signal as in a stepper motor.

Major Advantages of SR Motor

- Speed variable in a wide range
- Easy speed control implementation
- High torque at start-up
- Absence of brushes and magnetic parts
- Low manufacturing costs

Major Drawbacks of SR Motor

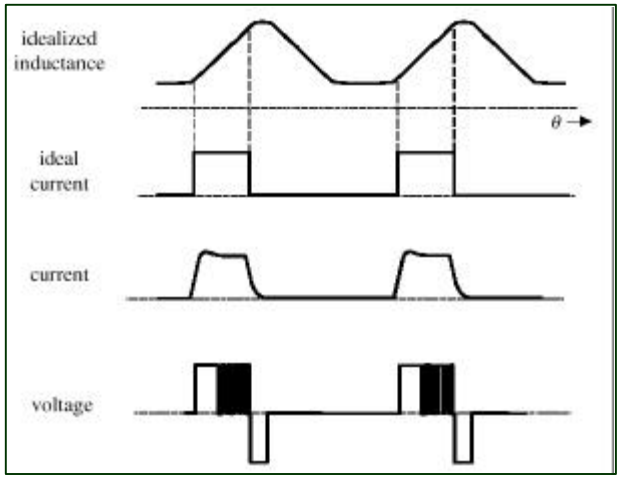
- Not directly on the mains
- Complex electronics for control
- High system costs

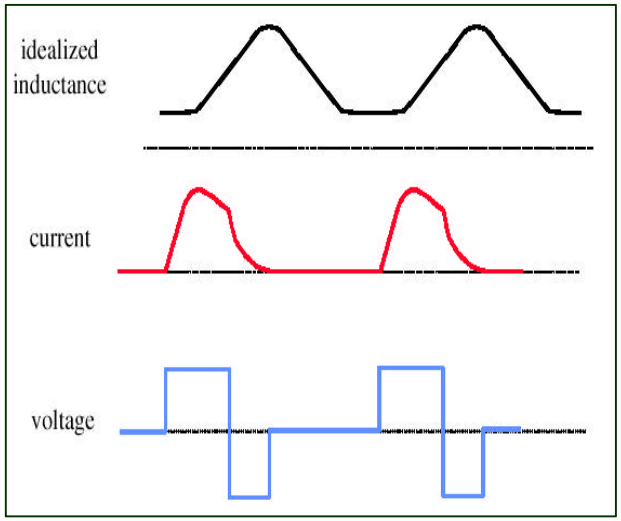


3-phase, 6/4 motor configuration

Typical Applications: Vacuum cleaners, Washing machines, Food processors

SRM drive with rotor position feedback



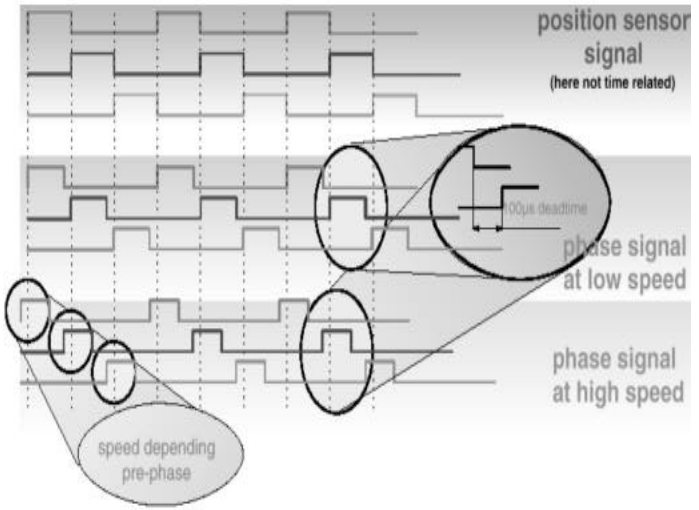


Since the relation linking the supplied torque T and the phase current *i* is

$$T = \frac{i^2}{2}\frac{dL}{d\theta}$$

current has to be supplied when the inductance L seen from each phase (and variable with rotor position with respect to stator phase) is rising in order to have positive torque.

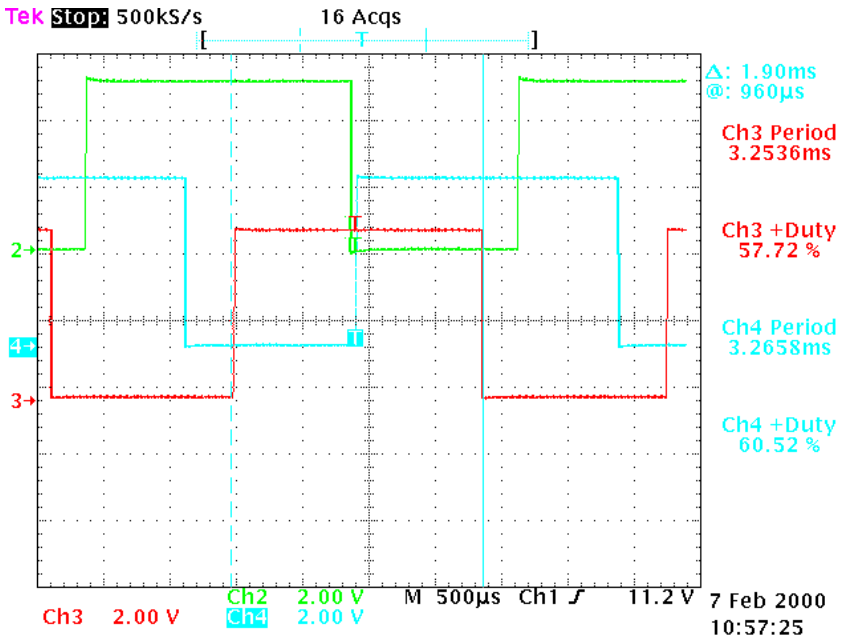
If current is supplied during L decreasing, a braking effect is obtained.



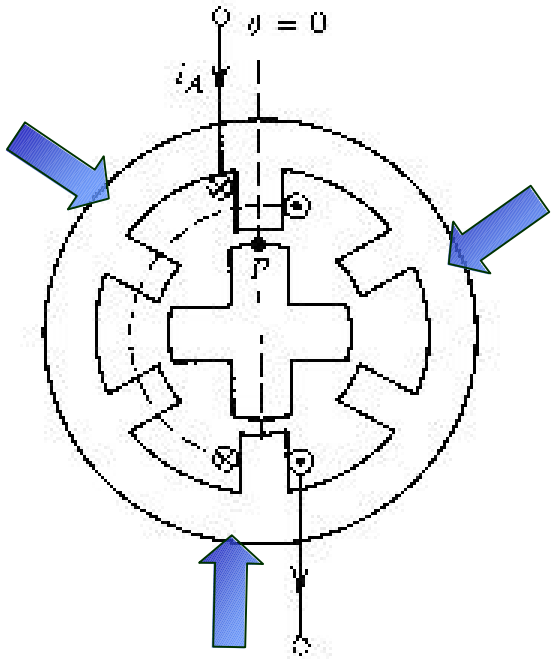
SRM Position Sensor Placement

Hall or photo-transistor sensors can be placed on the stator shaft to measure rotor position, therefore inductance variations.

Example of 3 photo-transistor sensors positioned at 120 degrees distance

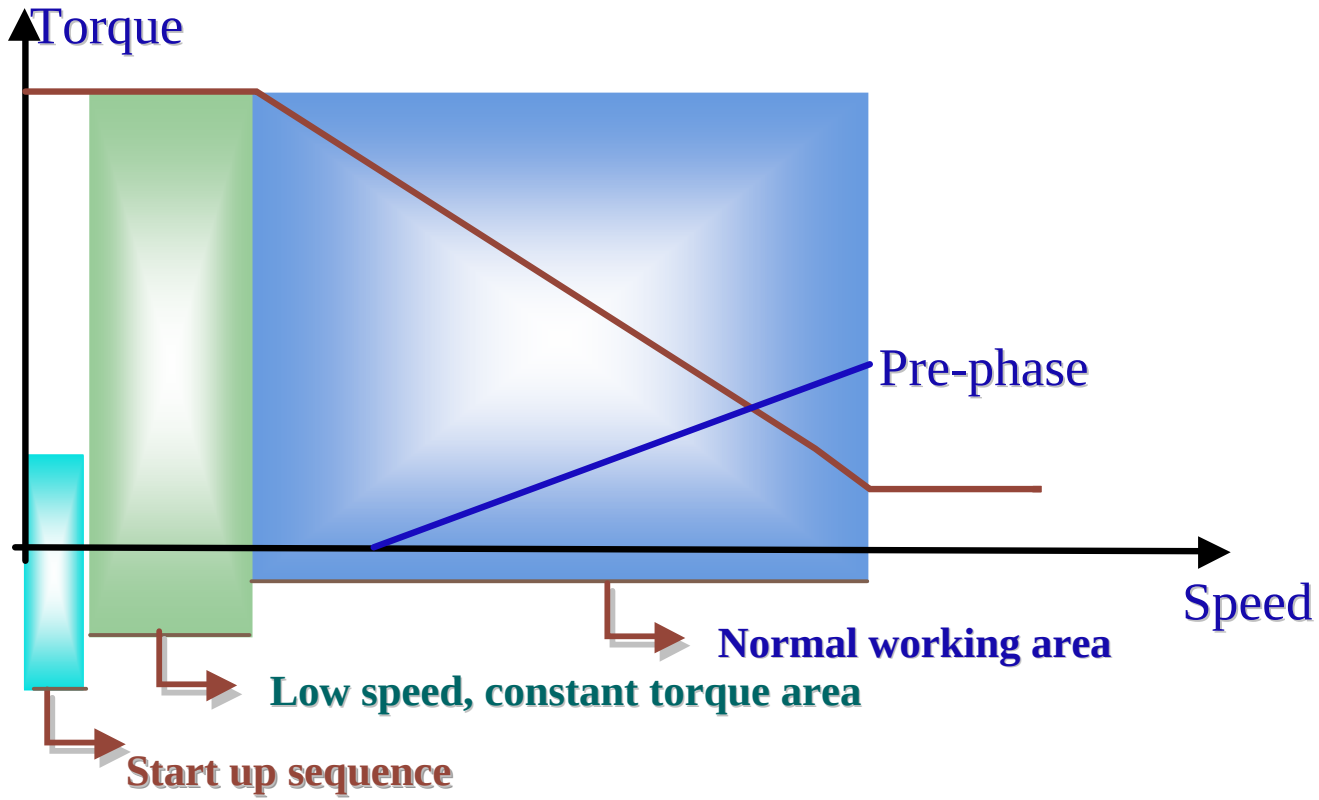


Sensors measures from oscilloscope



120 degree sensors position on a 6/4 SRM

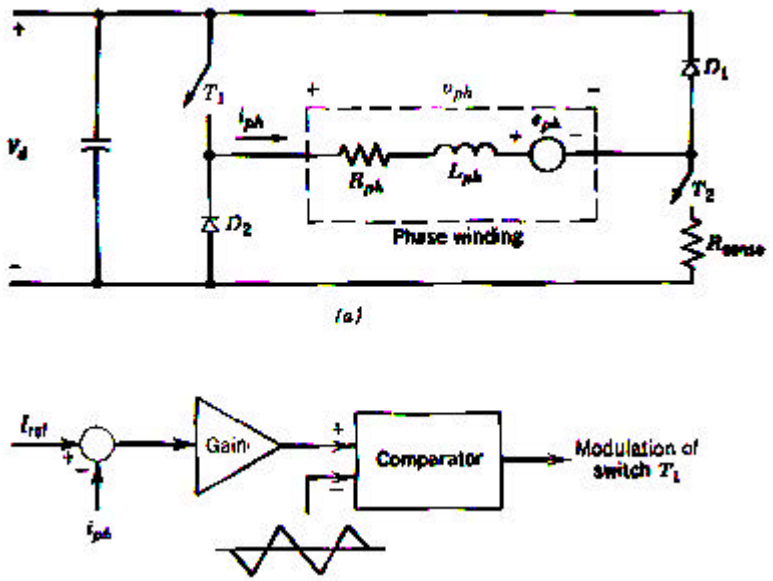
SR Motor Working Regions



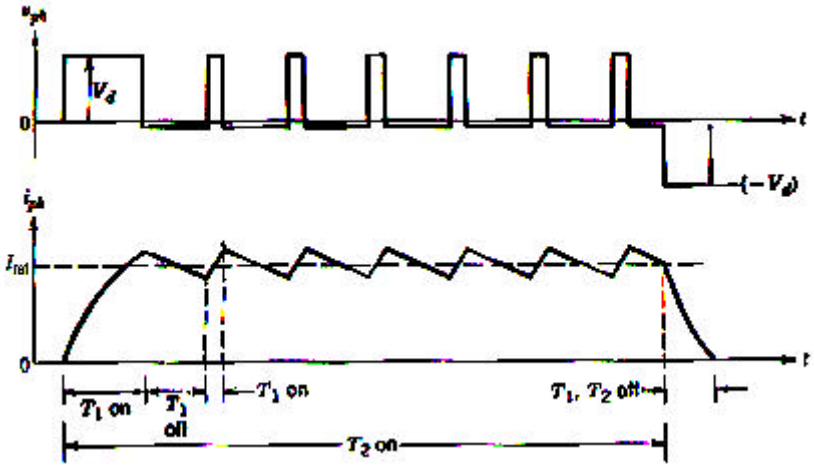
At high rotational speed, current rising time is comparable with duration of the inductance rising edge. In most cases this does not allow the current to rise at suitable levels to reach the desired torque: an anticipation in phase energizing **(pre-phase)** with respect to inductance rising start can be performed in order to have enough current and torque in the phase.

Current Mode Modulation (2N Switches)

With this technique, the magnitude of the current flowing into the stator windings is controlled using a control loop on a current feedback. The current winding in each phase is directly measured with a current/voltage converter or a current sense resistor connected in series with the phase. The current is compared with a desired value to calculate the error signal, that is compensated via a suitable control law.



Hardware topology of PWM Current Mode Control



V and I phase Waveform

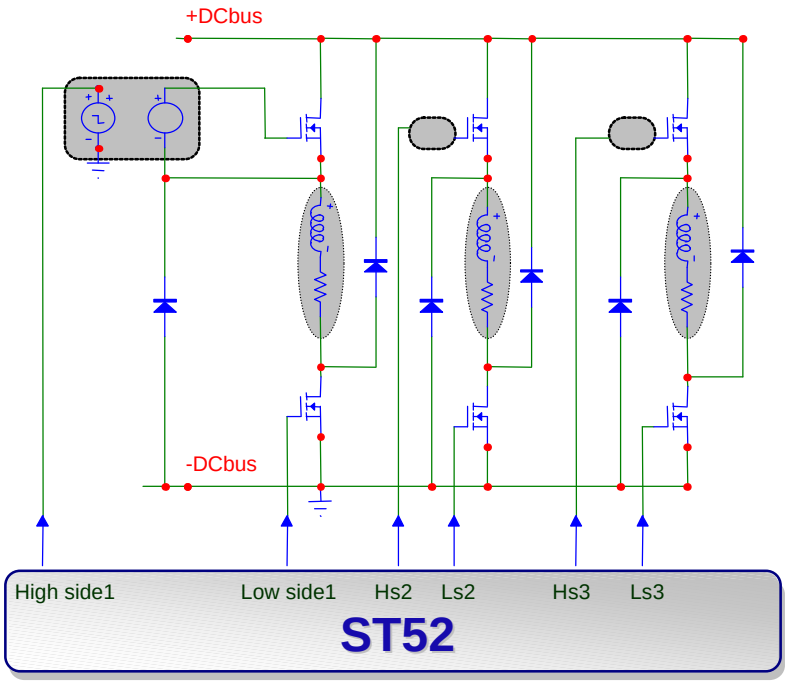
2n Switches Inverter Driver with ST52

Advantages

- Single phase current modulation
  (by using the pre-phase High-Side Switch)
- Fast phase turn-off
- Fastest phase de-energizing
- VBus fully exploitable

Drawbacks

- High cost (6 power switches + 3 drivers)
- High end microcontroller (6 independent control signals)



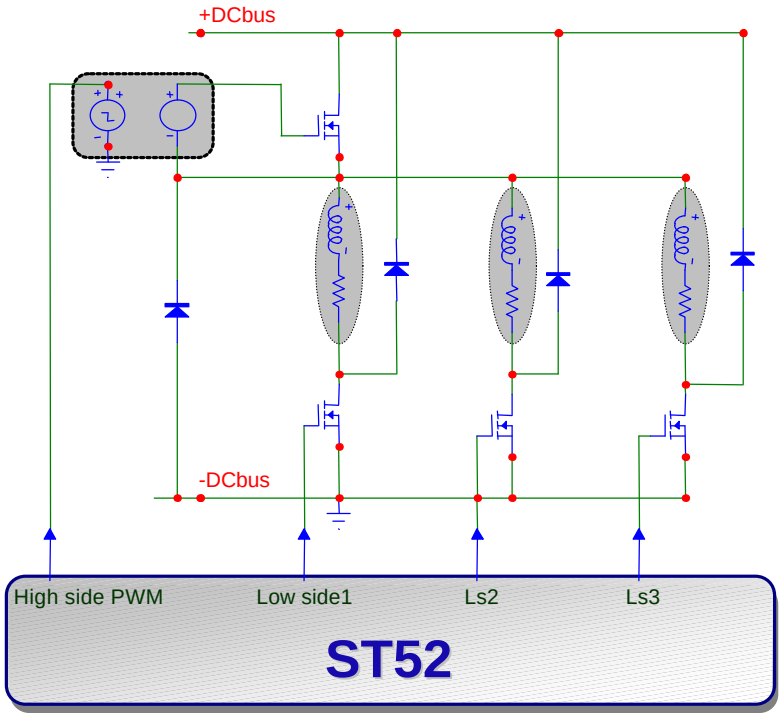
N+1 Switches Inverter Driver with ST52

Advantages

- Low cost (3 power switches + 2drivers)
- Low end microcontroller (4 independent control signals+ 1PWM)
- Only 1 fast switch and 4 slow switch

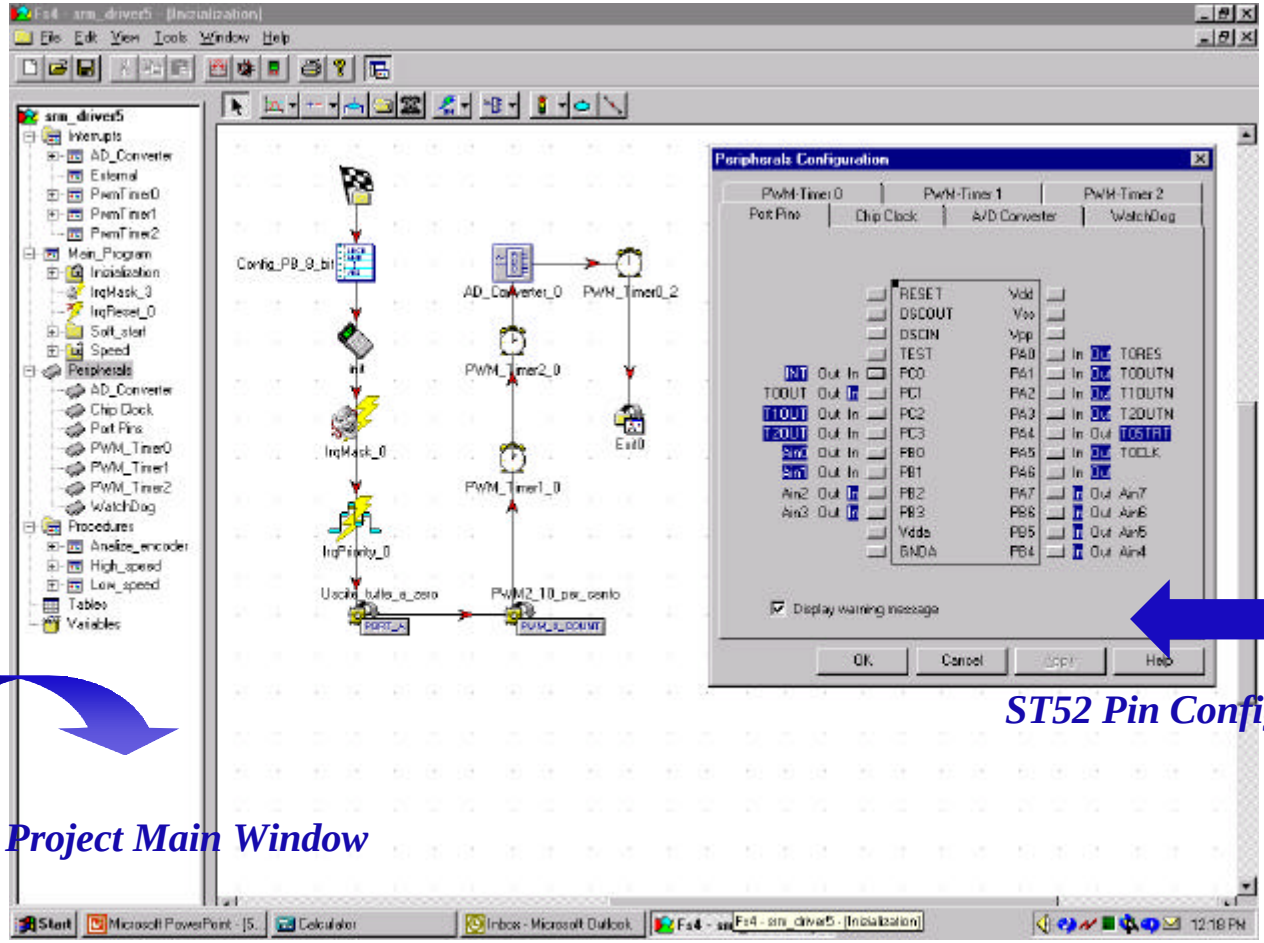
Drawbacks

- Current 'tail' after phase turn-off
- Common current phase modulation
- Vbus higher than rated motor voltage (PWM duty cycle <<100%)
- Less Torque capacity due to no phase overlap energizing possibilities



ST52 Software Development Tools: FuzzyStudio4.x

Fuzzy Studio4 allows to software design and debugging for **ST52x4yy** devices in a very simple and graphical way, that allows a fast prototyping phase.



ST52 Pin Configuration Window

Fuzzystudio Sw Project Main Window

Conclusions

Advantages

- SRM construction simplicity (absence of rotor coils, brushes, permanent magnets)
- Low cost motor
- High starting torque, wide speed range
- Low acoustic noise and electrical emissions with inverter drive stage
- Fast Prototyping phase thanks to ST52 sw development kit
- Easy design of control algorithms with Fuzzy Logic use

Drawbacks

- Need of customised control strategies
- Electronics cost

For further information see the ST52 Application Note page at http://mcu.st.com